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The influence of alloying or interdiffusion on the superconducting properties of ferromagnet/superconductor layered systems

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Abstract

We present the theoretical investigation of alloying or interdiffusion at the interface on the superconducting properties of ferromagnet/superconductor (S/F) layered films. The intermixed layer is modeled by the nonsuperconducting alloy (A) layer, which is characterized by strong scattering on paramagnetic impurities. The linearized Usadel equations are derived, which take into account the exchange scattering of excitations on the paramagnetic impurities in the alloyed layer. The superconducting transition temperature of the S/A/F trilayer is calculated as a function of spin-dependent scattering strength and thickness of A-layer. The nonmonotonic behavior of superconducting T_c at the onset of ferromagnetism in F-layer is discussed in the framework of the presented theory. The oscillations of T_c due to ferromagnetic layer thickness variation, and additional influence introduced by an alloy layer, are investigated.

Keywords: Interdiffusion; Superconducting transition; Superconductor/ferromagnet proximity effect

1. Introduction

Ferromagnet/superconductor (S/F) artificially layered systems has been the subject of extensive recent studies [1–13], because they combine two substances with antagonistic kinds of long range order. The key feature is that superconductivity has the ground state with zero total conduction electron spin, but ferromagnetism forces the maximum value of the total spin. Most of the recent studies have been directed to search for the oscillations of superconducting transition temperature T_c as a function of ferromagnetic layer thickness d_F, according to the scenario suggested by Buzdin and Kupriyanov [14] and Radović et al. [15]. The theory predicts T_c oscillations: in S/F bilayers or F/S/F trilayers as a result of interference of incident and reflected pairing wave functions in F-layer(s), or, in S/F multilayers, as a result of switching between "pi" and "zero" phase

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